TRANS WORLD COMMUNICATIONS, INC. ■ A Subsidiary of Datron Systems, Inc.

# TW500A
# LINEAR AMPLIFIER
# OPERATOR'S & TECHNICAL MANUAL

TRANSWORLD™
for communications

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304 Enterprise Street
Escondido, CA 92025, U.S.A.
Phone (619) 747-1079, Telex 695-433
Fax (619) 741-1658

# WARRANTY

Trans World Communications, Inc. (TWC) warrants that new TWC equipment has been manufactured free of defects in design, material and workmanship. If the equipment does not give satisfactory service due to defects covered by this warranty, TWC will, at its option, replace or repair the equipment free of charge.

The warranty is for a period of 90 days from the date of installation. In the event that the equipment is not installed within 90 days of factory shipment, satisfactory evidence of the installation date must be submitted.

### LIMITATIONS:

This warranty does not cover physical damage caused by impact, liquids or gases. Defects caused by lightning, static discharge, voltage transients, or application of incorrect supply voltages are specifically excluded from this warranty.

### RETURN OF EQUIPMENT - USA:

The equipment shall be returned freight prepaid to the Service Department, Trans World Communications, Inc., 304 Enterprise Street, Escondido, California 92025. The equipment should be packed securely, as TWC will not be responsible for damage incurred in transit. Please include a letter containing the following information:

1. Model, serial number, and date of installation.
2. Name of dealer or supplier of equipment.
3. Detailed explanation of problem.
4. Return shipping instructions.

TWC will return the equipment prepaid by United Parcel Service, Parcel Post or truck. If alternate shipping is specified, freight charges will be made collect.

### RETURN OF EQUIPMENT - FOREIGN:

Write for specific instructions. Do not return equipment without authorization. It is usually not possible to clear equipment through U.S. Customs without the correct documentation. If equipment is returned without authorization, the sender is responsible for all taxes, customs duties and clearance charges.

### LIMITED PARTS WARRANTY:

This warranty shall cover all parts in the equipment for a period of 12 months from the date of installation, subject to the previous conditions and limitations. The parts will be replaced free of cost. The labor charges will be made at the current TWC hourly service rate.

### PARTS REPLACEMENT:

If it is not practical, or the purchaser does not want to return the equipment to the factory, this warranty is limited to the supply of replacement parts for a period of 12 months from the date of equipment installation. The following instructions for the supply of replacement parts should be followed:

1. Return defective parts prepaid to: Parts Replacement, Trans World Communications, Inc., 304 Enterprise Street, Escondido, California 92025.

2. Include a letter with the following information:
    a) Part number(s).
    b) Serial number and model of equipment.
    c) Date of installation.

Parts returned without this information will not be replaced. In the event of a dispute over the age of the replacement part, components date coded over 24 months prior will be considered out of warranty.

# SAFETY CONSIDERATIONS

## GENERAL

This product and manual must be thoroughly understood before attempting installation and operation. To do so without proper knowledge can result in equipment failure and bodily injury.

### *CAUTION!*

Before applying ac power, be sure that the equipment has been properly configured for the available line voltage. Attempted operation at the wrong voltage can result in damage and voids the warranty. See the manual section on installation.

## EARTH GROUND

All TWC products are supplied with a standard, 3-wire, grounded ac plug. DO NOT attempt to disable the ground terminal by using 2-wire adapters of any type. Any disconnection of the equipment ground causes a potential shock hazard that could result in personal injury. DO NOT operate any equipment until a suitable ground has been established. Consult the manual section on grounding.

## SERVICING

Servicing should only be carried out by trained personnel. To avoid electric shock, do not open the case unless qualified to do so.

Various measurements and adjustments described in this manual are performed with ac power applied and the protective covers removed. The energy present at numerous points is sufficient to cause bodily harm, if contacted.

Capacitors (particularly the large power supply electrolytics) can remain charged for a considerable time after the unit has been shut off. Use particular care when working around them, as a short circuit can release sufficient energy to cause damage to the equipment and possible injury.

To protect against fire hazard, always replace line fuses with ones of the same current rating and type (normal delay, slow-blow, etc.). DO NOT use higher value replacements in an attempt to prevent fuse failure. If fuses are failing repeatedly, this indicates a probable defect in the equipment that needs attention.

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**TW500A Linear Amplifier.**

# SECTION 1
# GENERAL INFORMATION

## 1.1 INTRODUCTION

The TW500A linear amplifier is designed to amplify medium power (50-100 W PEP output) transmitters in the 2-30 MHz range. Power gain is approximately 10 dB and maximum rated power output is 500 W PEP. It operates from either 115 or 230 Vac, which is converted to approximately 14 Vdc by the internal power supply. The amplifier is suitable for SSB (voice) operation only. For CW, FSK or other high duty cycle use, an FSK option is available. See Section 1.9 below.

## 1.2 CONSTRUCTION

Highly reliable operation is achieved through an all solid-state design using eight transistors in four push-pull amplifier sections. Unlike vacuum-tube designs, all TW500A circuitry operates at low voltages, giving the components an extended service life and no maintenance requirements. In addition, the amplifier is completely broadband and requires no tuning or adjustment during service and installation.

The amplifier is housed in an anodized aluminum cabinet. (A rack-mounted version is also available.) All power transistors are mounted on a large, finned aluminum heat sink, which forms one of the main structural members of the enclosure. The self-contained power supply is located in the base of the amplifier. All controls are mounted on the front panel, as is a large, 100-A meter that indicates total collector current.

## 1.3 TRANSMIT/RECEIVE SWITCHING

Switching to the transmit mode is achieved by simply grounding the control line. Normally, this line is connected in parallel with the exciter push-to-talk (PTT) switch. In the receive mode, amplifier circuitry is bypassed, which provides direct connection of the antenna to the receiver. When off, the amplifier is bypassed for both transmit and receive functions.

## 1.4 HARMONIC FILTERING

Six computer-designed, low-ripple, Chebyshev low-pass filters are used to provide excellent harmonic rejection. The frequency range is divided into six bands and the correct filter for each must be selected. Provision is made for automatic selection by the exciter circuitry, or manual selection by the front panel switch (**optional** in desk-top models only).

## 1.5 PROTECTIVE CIRCUITRY

A high-speed, 75-A magnetic circuit breaker is provided in the dc power supply. This effectively protects the amplifier against short circuits, overdrive and mismatches.

To protect against thermal damage, an internal cooling fan is provided. When a heat sink temperature of 60°C is reached, the fan will automatically switch on, turning off again at 53°C.

## 1.6 EXCITER REQUIREMENTS

Input impedance of the amplifier is 50 ohms, which provides a good match to all exciters. The drive requirement is 50 W PEP, which is easily met by most equipment. Since the amplifier faithfully reproduces the input signal, it is important that the exciter be spectrally clean, or amplifier output will be similarly impure. Although amplifier harmonic output is substantially reduced by the output filters, it is desirable that exciter harmonics be suppressed by a minimum of 25 dB.

## 1.7 OPTIONS

For best system performance, it is desirable that an amplifier-output derived ALC system be used. The optional TWC SWR1000 forward/reverse power bridge has been specially designed for this purpose. Consult Section 2, Installation, for more information.

**NOTE**

The SWR1000 is standard equipment on all TWC HF communications systems incorporating the TW500A amplifier.

## 1.8 SPECIFICATIONS

Amplifier specifications are listed in Table 1-1. These specifications are the standards or limits against which the amplifier can be tested.

## 1.9 FSK OPTION

The FSK option should be installed in any system where there is a high duty cycle such as FSK or CW operation.

**TABLE 1-1.**
**TW500A Technical Specifications.**

| | |
|---|---|
| OPERATING FREQUENCY: | 2-30 MHz. |
| POWER OUTPUT: | 500 W PEP minimum, 500-600 W PEP typical. FSK Option - 400 W Average CW/FSK. |
| INTERMODULATION DISTORTION (2-24 MHz) @ 500 W PEP: | -32 dB 3rd order. |
| HARMONIC FILTERS: | 5-pole, Chebyshev low-pass. |
| HARMONIC OUTPUT: | -43 dB or better. |
| INPUT/OUTPUT IMPEDANCE: | 50 ohms (S0-239 connectors). |
| DRIVE REQUIREMENTS: | 50 W PEP. |
| POWER REQUIREMENTS: | 115/230 Vac, 50/60 Hz, single phase. |
| TRANSMIT/RECEIVE SWITCHING: | Grounded control line. Amplifier is bypassed when switched off. |
| COOLING: | Convection-cooled heatsink with supplementary forced air. |
| POWER SUPPLY PROTECTION: | 75-A, high-speed magnetic circuit breaker. |
| FUSES: | (115 V) 15 A; (230 V) 7 A. |
| STANDARD CABINET VERSION: | Size (WHD): 44 x 20 x 33 cm. |
| | Weight: 21 kg. |
| RACK-MOUNT VERSION: | Size (WHD): 48 x 29 x 33 cm. |
| | Weight: 19.5 kg. |

*NOTE: All specifications measured with line voltage of 115 or 230 Vac measured at amplifier under load.*

# SECTION 2
# INSTALLATION

## 2.1 PLACEMENT

The amplifier may be placed on any flat surface adjacent to the exciter or in any other convenient location. Make sure that it is kept out of direct sunlight and other sources of heat. To allow proper air flow, the cooling vents in the base and sides of the amplifier cabinet must NOT be obstructed.

## 2.2 AC POWER CONNECTION

***IMPORTANT!***

Check the voltage requirements of your amplifier before applying ac voltage. *The amplifier must be properly configured for the local ac mains or damage can occur.* Set-up is accomplished by properly connecting wires to the terminal block, as shown in Figure 2-1. Access to the terminal block is gained by removing the four retaining screws located on each side of the unit and removing the case. Note that there is no case on rack-mount versions.

Also be sure to install the proper fuse, F1, according to the ac voltage chosen. Correct values are: 7 A for 230-Vac and 15 A for 115-Vac operation. The fuse is accessible from the rear panel.

Although the rated supply voltage is 115/230 Vac, the amplifier will operate properly with supply voltages from 115-120 or 230-240 Vac.

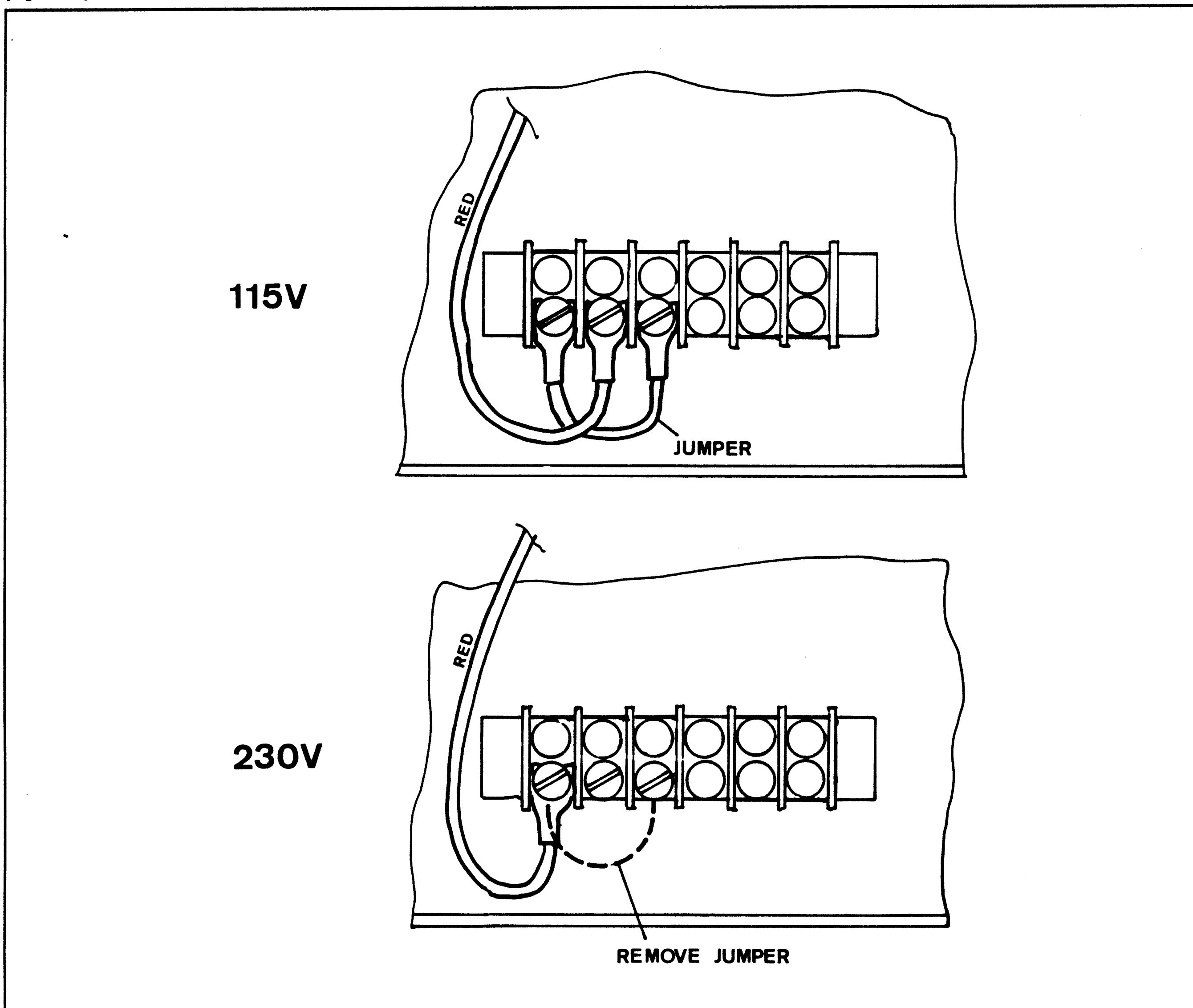



**FIGURE 2-1.**
**Variations in Terminal Block Wiring to Accommodate 115- or 230-Vac Operation.**

**_IMPORTANT!_**

Operation at lower-than-rated supply voltages will result in reduced RF power output.

## 2.3 GROUNDING

A separate ground connection is recommended to prevent unwanted RF currents from circulating in the amplifier chassis and wiring. These currents can induce feedback and distortion in the exciter and cause RF burns when the equipment is touched. This ground connection is *essential* if the antenna is located close to the amplifier.

Grounding should be provided as shown in Figure 2-2. A grounding post on the back panel is used for this purpose. Use a heavy-gauge copper wire or strap for the connection, and keep it as short and direct as possible. A good ground can be made by driving a 2-meter rod into moist soil, or by making the connection to a cold water pipe.

## 2.4 ANTENNA CONNECTION

Output impedance of the amplifier is 50 ohms, and a heavy-duty coaxial cable (RG-8/U or similar) should be used for connection to the antenna or the antenna tuner (Figure 2-2). A PL-259 UHF connector must be fitted to the cable end (see Appendix A). Make sure that it is securely soldered and tightened, as peak RF currents will reach 2-3 A at full output.

## 2.5 ANTENNA MATCHING

The linear amplifier is suitable for use with any antenna or antenna tuner having a nominal 50-ohm impedance and 600-W power handling capability. Correct antenna impedance matching is extremely important if the amplifier is to deliver rated power output.

Unlike tube-type amplifiers, the TW500A is completely broadband, with no tuning adjustments of any kind. Therefore, it is not possible to compensate for any mismatch in the antenna system. This characteristic must be clearly understood if satisfactory results are to be achieved.

Output transformers in the amplifier have been designed for a 50-ohm resistive load, and will not deliver full power into a substantial mismatch. For example, consider that RF voltage at the output essentially remains constant, regardless of load. With a power output of 600 W into a 50-ohm load, the output voltage is 173 $V_{RMS}$ (E = P x R). The same voltage across a 100-ohm load (VSWR = 2:1) equals only 300 W, or half power ($P = E^2 / R$). Similarly, if the load is less than 50 ohms, the amplifier will automatically current limit and output will be less than rated.

Antenna matching should be checked carefully by using a VSWR indicator in the coaxial cable to the antenna. The antenna or tuner should be adjusted for the lowest possible reflected power. Although an exact match is desirable, the amplifier will operate satisfactorily with a VSWR of 1.5:1. Operation with a 2:1 VSWR will result in substantially reduced output, and it is recommended that this level not be exceeded.

## 2.6 EXCITER CONNECTIONS

Two connections to the exciter are always required: RF input and transmit/receive control (Figure 2-2). A third connection is needed for remote selection of the harmonic filters, *and is essential on all rack-mounted versions.* Input to the amplifier is made through a 50-ohm coaxial

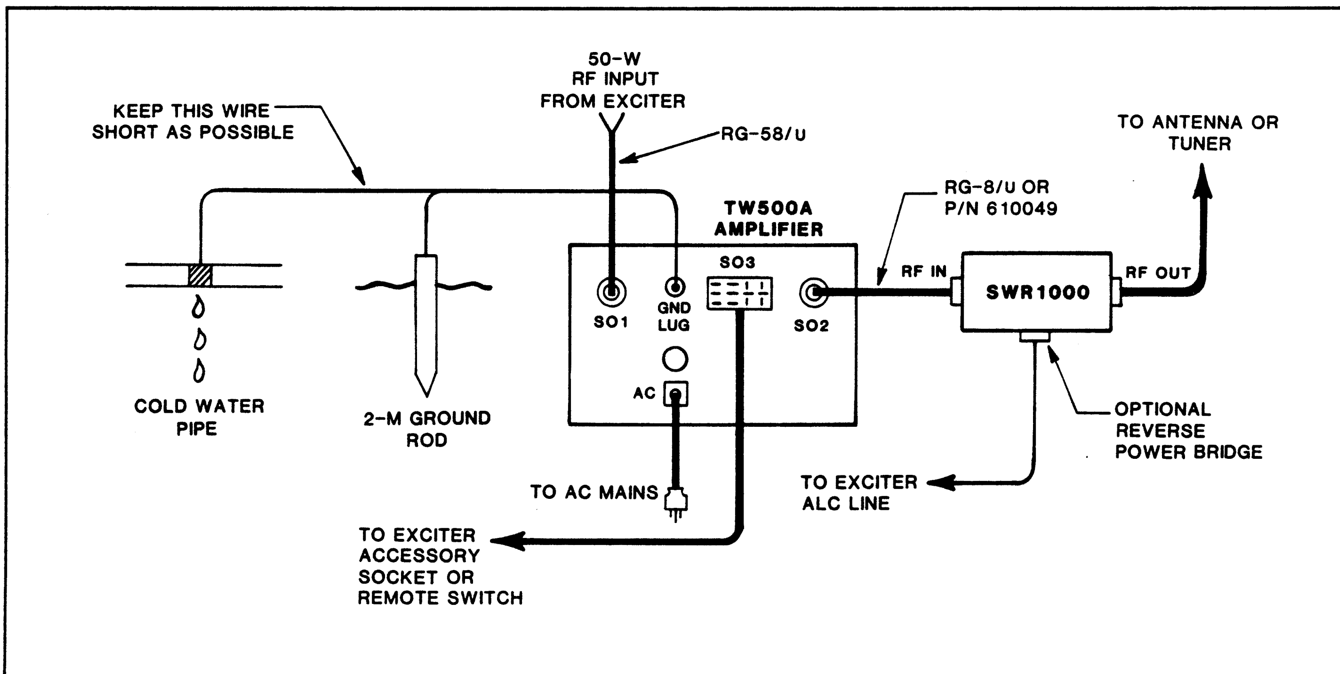



**FIGURE 2-2.**
**Ground, Exciter and Antenna Connections to the TW500A.**

cable (RG-58/U or similar), which is terminated in a PL-259 UHF connector.

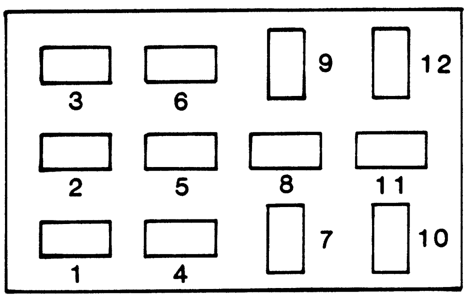
Grounding the PTT line switches the amplifier from the receive to the transmit mode. Connection to this line is made at Pin 10 of the remote socket, SO3, located on the back panel (Figure 2-3). Grounding can be achieved by a relay in the exciter or through the microphone PTT switch. Operating voltage for the PTT line is 12 Vdc at 140 mA.
If the microphone PTT switch is used to key both the exciter and the amplifier, interaction can sometimes result. In this event, a simple but effective circuit can be used to provide the necessary isolation (Figure 2-4).

## 2.7 FILTER SWITCHING

***IMPORTANT!***

The correct low-pass filter for the operating frequency must be selected to avoid excessive harmonic emission and possible damage to the amplifier.

The TW500A incorporates 6 filter bands to cover the operating frequency range of 2-30 MHz: 2-3, 3-5, 5-8, 8-13, 13-20 and 20-30 MHz. Filter selection can be made




SO3 REMOTE SOCKET

SO3 CONNECTIONS

| PIN NO. | FUNCTION |
|---|---|
| 1 | 2-3 MHz |
| 2 | 3-5 MHz |
| 3 | 5-8 MHz |
| 4 | 8-13 MHz |
| 5 | 13-20 MHz |
| 6 | 20-30 MHz |
| 7,8,9 | GND |
| 10 | PTT |

**FIGURE 2-3.**
**Transmit/Receive and Remote Filter Selection Connections.**

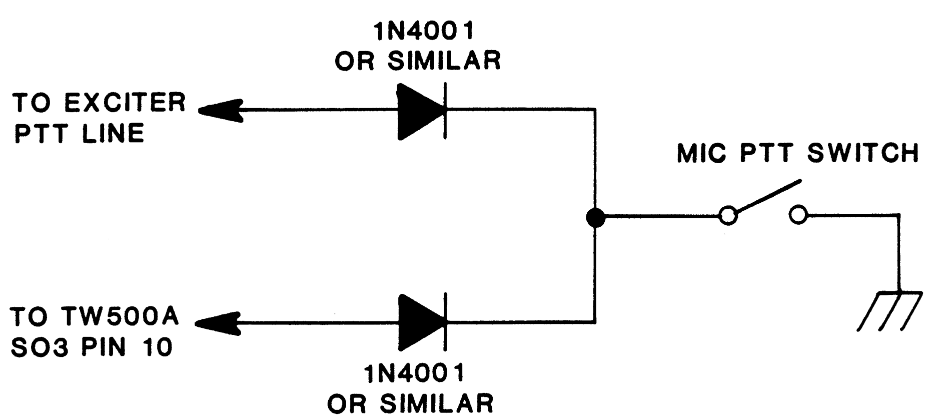



**FIGURE 2-4.**
**Circuit to Provide Additional Amplifier-to-Exciter PTT Line Isolation.**

either by using the front-panel switch, or by grounding the appropriate pin on remote socket SO3 (Figure 2-3). If remote switching is used, the contacts should be rated to handle 12 Vdc at 140 mA. Note that the front panel filter switch is not installed on the rack-mount version.

Most transmitters have an extra section ganged to the channel switch for remote control of an amplifier or other accessory. Frequency-synthesized HF transmitters often have a switching contact coupled to the "MHz" logic line that can be used to provide automatic filter selection. Refer to Figure 2-5 for examples of filter-selection circuitry. (In some complex systems it may be necessary to provide a diode control matrix to control filter selection. Contact the factory for additional information.)

## 2.8 BIAS ADJUSTMENT

The forward bias adjustment is properly set at the factory and normally should not need adjustment. However, a large variation in line voltage may necessitate a slight readjustment. To check if the bias is set properly, ground the amplifier PTT line with NO DRIVE APPLIED, and monitor the front-panel meter. It should read 3.5 A ± 0.5 A. If not, turn to Section 5.5 for instructions.

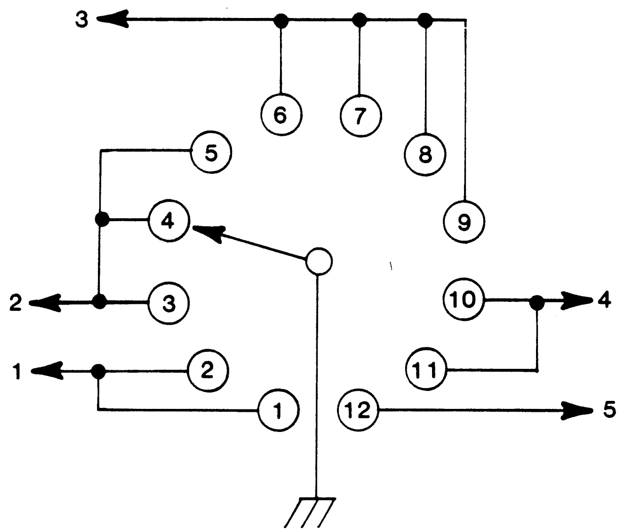
## 2.9 DRIVE REQUIREMENTS

CAUTION!

The normal drive level for full output should not exceed 50 W! Care must be taken to not overdrive the amplifier, which can destroy the expensive power transistors and void the warranty. If the exciter is capable of exceeding 100-W output, it is recommended that some means be used to restrict the power level.

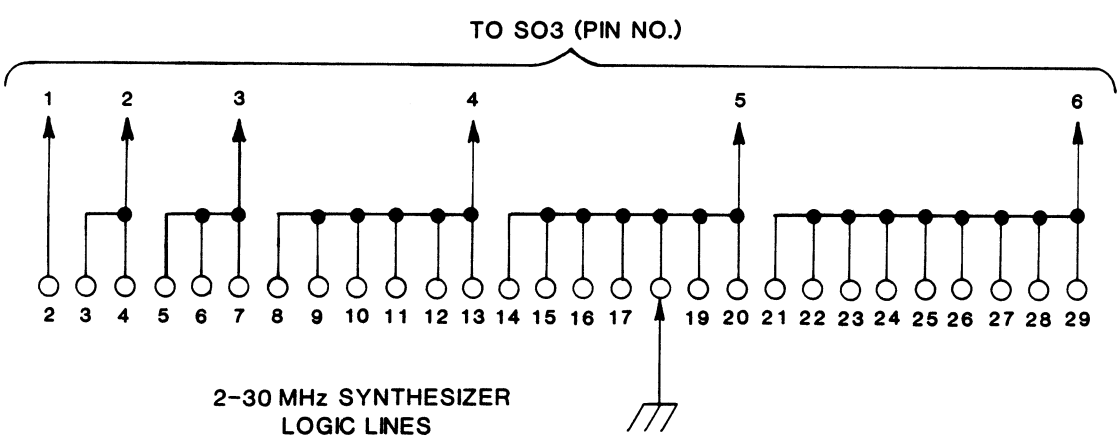
For best system performance over a wide range of frequencies, it is desirable to utilize an automatic level control (ALC) system to dynamically limit drive power. The preferred method is to generate an ALC voltage from the amplifier output, which is then fed back to the exciter. One such device for this purpose is the TWC SWR1000 forward/reverse power bridge. This is a specially-designed sensing device that can be configured to provide a positive voltage either proportional or inversely proportional to the forward power level. Use of the SWR1000 is shown in Figure 2-2. Refer to Figure 6-2 in Section 6 for a schematic diagram of the SWR1000.

When the SWR1000 is installed and used with a compatible transceiver like the TWC TW100, then setting the overall system power output is quite easy. After the system is installed and hooked up as shown in Figure 2-2, the "ALC" adjustment on the SWR1000 is used to set the power. The operating frequency should be set for 15 MHz, the transceiver keyed in CW mode, and the SWR1000 "ALC" screwdriver adjustment turned until the RF power output is 400 watts as read on a Bird thruline wattmeter with the amplifier terminated in 50 ohms. No other adjustment is required.




| EXCITER CHANNEL | OPERATING FREQUENCY | SO3 PIN NO. |
|---|---|---|
| 1 | 2.2 MHz | 1 |
| 2 | 2.7 MHz | 1 |
| 3 | 3.1 MHz | 2 |
| 4 | 4.4 MHz. | 2 |
| 5 | 4.9 MHz | 2 |
| 6 | 5.3 MHz | 3 |
| 7 | 5.7 MHz | 3 |
| 8 | 5.8 MHz | 3 |
| 9 | 7.9 MHz | 3 |
| 10 | 8.2 MHz | 4 |
| 11 | 12.7 MHz | 4 |
| 12 | 15.9 MHz | 5 |

**(A)**




**(B)**

**FIGURE 2-5.**
**Filter Selection, Circuitry Examples.**
**Remote filter switching can be provided by a simple bandswitching arrangement (A),or by coupling to the logic lines of a synthesized radio (B).**

# SECTION 3
# OPERATION

## 3.1 GENERAL

Unlike vacuum-tube amplifiers, the TW500A has no tuning adjustments and requires no operator skills. Harmonic filter selection can be made automatically by the exciter circuitry. Operation, therefore, is simply a matter of setting the correct drive level. If the exciter utilizes an ALC system, the drive level can be preset.

***IMPORTANT!***

The amplifier must be properly installed to meet performance specifications. Refer to manual Section 2 before attempting operation.

## 3.2 CONTROLS

(For discussion below, please refer to Figure 3-1).

### 3.2.1 ON-OFF SWITCH/CIRCUIT BREAKER

Ac power to the amplifier is switched on and off by the front panel rocker switch, which also controls the power-on light. When in the off position, the amplifier is bypassed for both transmit and receive. If collector current exceeds 75 A, the circuit breaker will trip, forcing the amplifier off and the trip light on. Excessive tripping of the circuit breaker usually indicates a problem, such as overdrive or improper antenna matching. See Service/Maintenance, Section 5, for a discussion of possible problems.

### 3.2.2 HARMONIC FILTER SELECTION

***CAUTION!***

Amplifier circuitry is NOT protected against improper filter selection. Failure to select the appropriate filter can result in damage and will void the warranty.

With most exciters, filter selection is automatic, or in the case of desk-top models, by optional manual control. If a control is provided, turn it to the "REMOTE" position for automatic selection. For manual control, simply turn the switch to the proper frequency band.

## 3.3 DRIVE LEVEL ADJUSTMENT

***IMPORTANT!***

Before setting the drive level, make sure that the amplifier is operating into a 50-ohm load.

If no test equipment is available, speak into the microphone, and slowly increase the exciter drive level

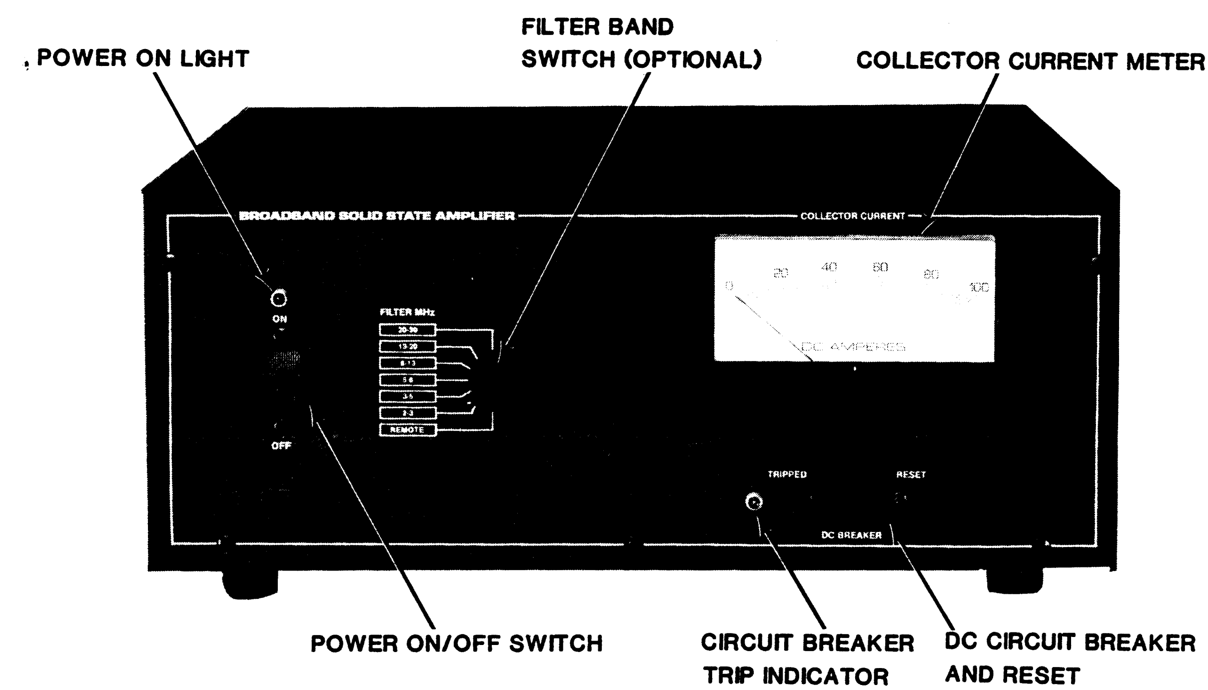



**FIGURE 3-1.**
**Front Panel Features of the TW500A.**

If no test equipment is available, speak into the microphone, and slowly increase the exciter drive level until the collector current meter reads 50-60 A on voice peaks. DO NOT increase drive level beyond this point in an attempt to deliver more power, as distortion will occur.

Because the current meter reading is dependent on voice characteristics, it is recommended that an oscilloscope be used to monitor the output waveform when setting the drive level. Connect the amplifier to either a dummy load or an antenna, and place a coaxial "T" fitting in the output line. The oscilloscope is then connected to the "T" (Figure 3-2). While speaking into the microphone, slowly increase exciter drive until peak flattening of the amplifier output is just noticeable, then reduce it to where the waveform is undistorted (Figure 3-3).

**NOTE**

Some oscilloscopes cannot accept the approximately 500 $V_{P-P}$ produced at full power output. In this event, a reducing-type probe should be used, or alternatively, a 20-30 dB RF attenuator may be put in the output line. The scope can then sample the lower voltage found on the load side of the attenuator.

If the exciter is provided with adjustable ALC, set it to limit drive as prescribed by one of the two methods above. If the SWR1000 is used with a compatible transceiver, the RF power output can be set as described in Section 2.9.

### 3.4 COOLING FAN

The internal cooling fan will automatically operate if the heat sink temperature exceeds 60°C. During intermittent SSB operation, it is common for the fan to remain off.

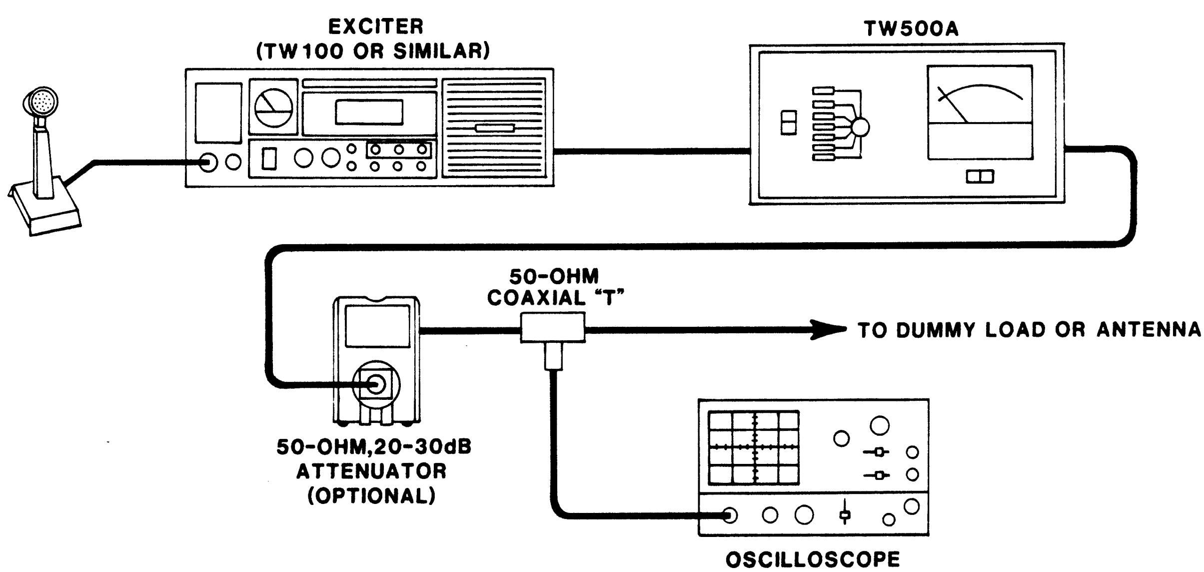
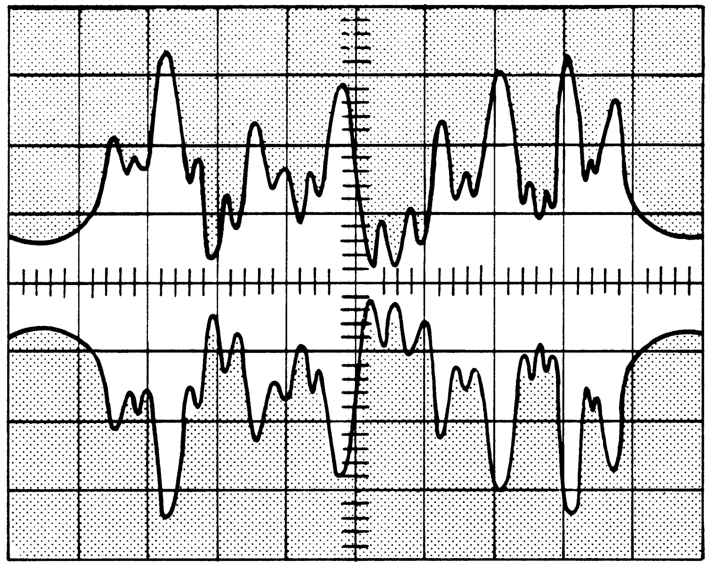
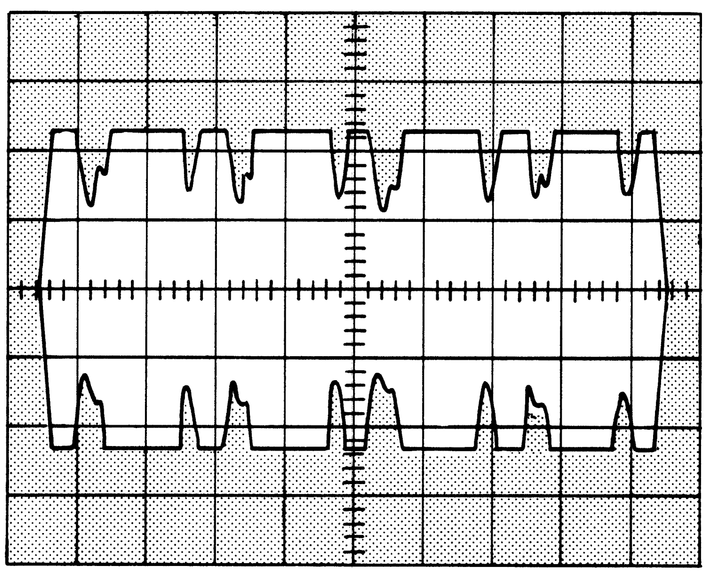



**FIGURE 3-2.**
**Test-Equipment Setup for Adjusting Exciter Drive Level.**



**(A)**



**(B)**

FIGURE 3-3.
Monitoring the Output Waveform.
Scope patterns of a speech waveform show a properly-driven amplifier at (A),
and characteristic "flat-topping" of the waveform due to overdrive at (B).

# SECTION 4
# TECHNICAL DESCRIPTION

## 4.1 GENERAL

The TW500A consists of four push-pull transistor amplifiers, each with input and output impedances of 200 ohms (Figure 4-1). All four sections are paralleled through an input splitter and output combiner, which provides composite 50-ohm input and output impedances.

Input from the exciter is fed through a compensating network, which provides constant amplifier gain throughout the entire frequency range. RF output is coupled to the antenna through one of six low-pass harmonic filters.

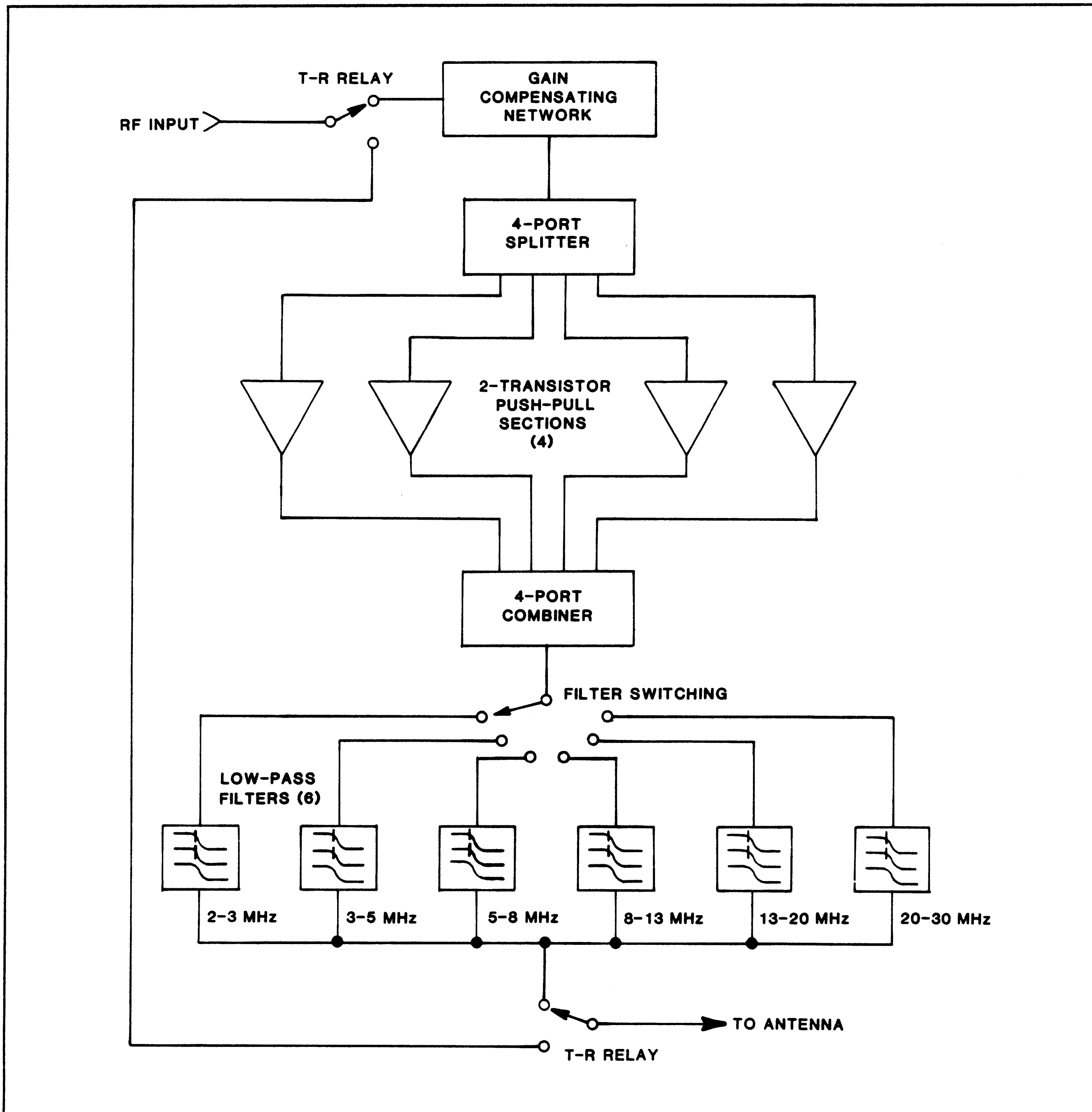



**FIGURE 4-1.**
**Block Diagram of TW500A RF Circuitry.**

(For the following descriptions, refer to the fold-out schematic, Figure 6-1, in Section 6 of the manual.)

### 4.2 INPUT CIRCUIT

Matching the four amplifier inputs over the 2-30 MHz frequency range provides a complex design problem. While the "real" input impedance changes by a factor of almost 10, device gain varies by approximately 8 dB.

If each amplifier were identical in all respects, the four 200-ohm inputs could be directly paralleled to give a combined input impedance of 50 ohms. In practice, the slight mismatch between amplifiers prevents satisfactory operation. To counter this problem, a splitter is used to parallel the inputs, and also provide good port-to-port isolation. Any components resulting from imbalance will be shunted by the non-inductive combiner resistors and dissipated as heat.

Excellent transfer characteristics of the four input transformers and splitter make it possible to use a single gain-compensation network at the input, rather than individually compensating all eight transistors. The computer-designed network, consisting of L1, L2, R1, R2, C3 and C4, provides a low input VSWR and level gain across the operating frequency range.

### 4.3 AMPLIFIERS

Each of the four amplifier sections is a simple push-pull design using two 80-W, broadband linear power transistors. These devices feature an emitter-ballasted chip design to control impedance and gain over a decade of bandwidth.

Figure 6-1 shows how each pair of transistors is connected in a conventional, transformer-coupled, push-pull circuit. Special ferrite-loaded, broadband transformers T1-T4 provide the correct impedance transformation with high efficiency over the 2-30 MHz range.

For maximum efficiency and linearity, the amplifier sections operate in Class AB. The low-impedance bias source is provided by transistors Q1 and Q2. Thermal compensation for the 2 mV/ °C emitter/base voltage change of the output transistors is provided by Q1, which is mounted on the heat sink. The bias regulator provides a stable current source with excellent thermal tracking.

### 4.4 OUTPUT CIRCUIT

The output circuit utilizes broadband transformers T5-T8 for impedance matching. A four-port output combiner, similar in design to the input splitter, provides port-to-port isolation and dissipation of any imbalance products.

### 4.5 HARMONIC FILTER

All broadband transistor amplifiers have a relatively high level of harmonic output. In a push-pull circuit, the even-order (2nd, 4th, etc.) harmonics tend to cancel out, but the odd order (3rd, 5th, etc.) ones are not attenuated. An output filter is essential to maintain spectral purity. The TW500A utilizes low-loss, 5-pole Chebyshev filters with low reflection coefficients.

Six filters are used to cover the frequency range, which is divided up into 2-3, 3-5, 5-8, 8-13, 13-20 and 20-30 MHz. Individual relays are used at the input and output of each filter, which allows selection by remote control.

### 4.6 CONTROL CIRCUITRY

Transmit/receive switching is accomplished by two relays, K1 and K14. In the receive or off positions, SO1 and SO2 are connected together so that the amplifier is completely bypassed. In the transmit mode, relay K1 connects the RF input to the input combiner and also feeds bias voltage to the amplifiers. K14 routes the amplifier output to SO2.

The cooling fan is controlled by thermostat TH1, which is mounted on the heat sink. It switches on when the temperature reaches 60° C. The fan switches off automatically when the temperature drops to 53°C.

### 4.7 POWER SUPPLY

The amplifier power supply provides a nominal 14 Vdc at peak currents of 75 A. Because it is unregulated, supply voltage is 18 Vdc without any load, dropping approximately 4 V on sustained output peaks. Although most amplifier designs use regulated power supply sources, tests have shown that with properly designed bias circuitry, there is no degradation of linearity over moderate variations in supply voltage. The benefit of such an approach is increased reliability and efficiency, with much less heating. Transistor reliability in the TW500A is not sacrificed, as the breakdown point of 32 V is well below the unloaded power supply value.

In order to optimize voltage stability without resorting to active regulators, four separate transformers and 35-A, full-wave bridge rectifiers are used. All the transformers have 115-Vac primaries, which are connected in series-parallel for 230-Vac operation and in parallel for 115-Vac operation. The individual dc outputs are paralleled to provide the required current. Filtering is achieved by two 110,000-µF, computer-grade electrolytic capacitors.

# SECTION 5
# SERVICE

**_CAUTION!_**

*Although the highest dc voltage in the amplifier does not exceed 20 V, very high RF voltages are present during operation. While RF voltages are generally not lethal, they can cause unpleasant burns, which demands that care be taken when servicing. The power supply is capable of very high currents and measures should be taken to avoid short circuits. Apart from the fire hazard, short circuits are likely to cause severe physical and electrical damage to the amplifier.*

## 5.1 INTRODUCTION

The TW500A requires no routine maintenance. All power transistors are rated for an extended service life and replacement is necessary only in the event of a failure. Low-voltage operation is a major contributor to the maintenance-free operation.

To ensure reliability and long service life, the amplifier should be operated into a proper load and must not be overdriven. Although the power transistors are rated for operation at infinite VSWR, *prolonged operation into mismatched loads will cause excessive heat dissipation and eventual failure.*

## 5.2 INITIAL CHECKS

Problems with the amplifier are generally manifested in one of the following ways:

1) A fuse blows or a circuit breaker trips.
2) The collector current meter reads abnormally high or low, with reduced power output.
3) The amplifier does not function on certain frequencies.
4) The output signal is distorted.
5) The unit is totally inoperative.

Should any of the above conditions occur, first review Section 2, Installation, to be sure that the problem is not external to the amplifier. For example, conditions 1 and 2 above can result from overdrive, a poor antenna or improper filter selection. Condition 3 usually indicates a problem with the filter board. Improper bias level or a defective power transistor can cause condition 4, while a major power supply failure will cause condition 5.

If the problem is in the amplifier, without the source being obvious, a system of routine checks should be performed to isolate the trouble. One should check the main power supply, the bias circuit, the amplifier circuits and the filter board--in that order. The following sections provide details concerning service in these areas.

## 5.3 POWER MEASUREMENT

In commercial service, it is normal to rate amplifiers according to power output. This will vary according to the input power and amplifier efficiency. The best method of measuring SSB output power is to use a peak-reading RF voltmeter (calibrated in $V_{RMS}$) connected across a non-reactive, 50-ohm load. Output power is then determined by: $E^2$ ($V_{RMS}$) / 50 = W PEP (158 $V_{RMS}$ = 500 W PEP).

An oscilloscope can also be used to measure the peak-to-peak voltage across the load, with power determined by: $E^2$ ($V_{P-P}$)/141 = W PEP (447 $V_{P-P}$ = 500 W PEP). Since the frequency response of an oscilloscope often falls off toward the upper HF range, be sure to calibrate it at the operating frequency. Both the peak-reading voltmeter and oscilloscope can be used to measure the power output of voice, two-tone test signal and CW waveforms.

A conventional wattmeter measures the <u>average</u> power output and is only accurate for CW signals. When using a standard wattmeter, the PEP output can be measured by applying a two-tone test signal. In this case, the wattmeter will indicate 50% of the actual PEP output (500 W PEP = 250 W avg.). On a voice waveform, the average-to-PEP ratio is even greater, and the indicated output power will greatly depend on voice and meter characteristics. The reading may only be 20-40% of the true PEP and is generally not a meaningful indication.

## 5.4 CIRCUITRY ACCESS

Access to the amplifier and filter circuit boards is gained by removing the four retaining screws on each side of the amplifier and lifting the cover up (Figure 5-1). Note that rack-mounted versions are not supplied with a cover. The power supply, which is mounted in the lower part of the amplifier, can be accessed by removing the screws holding the heat sink in place and lifting it up and out of the way (Figure 5-2).

## 5.5 POWER SUPPLY

The power supply is very simple, consisting of transformers T9-T12 and full-wave bridge rectifiers BR1-BR4, all configured in parallel (Figure 6-1). Operation of each supply can be checked by disconnecting the wire from the positive terminal of each bridge rectifier, and inserting an ammeter (25 A) between the two. Under load, the current from each bridge rectifier will be similar (25% of total current) unless one is faulty.

A static test of each bridge rectifier can be made by using an ohmmeter to check the diodes in each leg. With all four leads disconnected from the bridge, resistance between two adjacent terminals should be high in one direction (thousands of ohms), and relatively low in the other.

Transformer faults are unlikely, as the two windings in each consist of heavy-gauge wire. Winding continuity can be checked with an ohmmeter, as can winding isolation from ground. Filter capacitor shorts will blow the primary fuse,

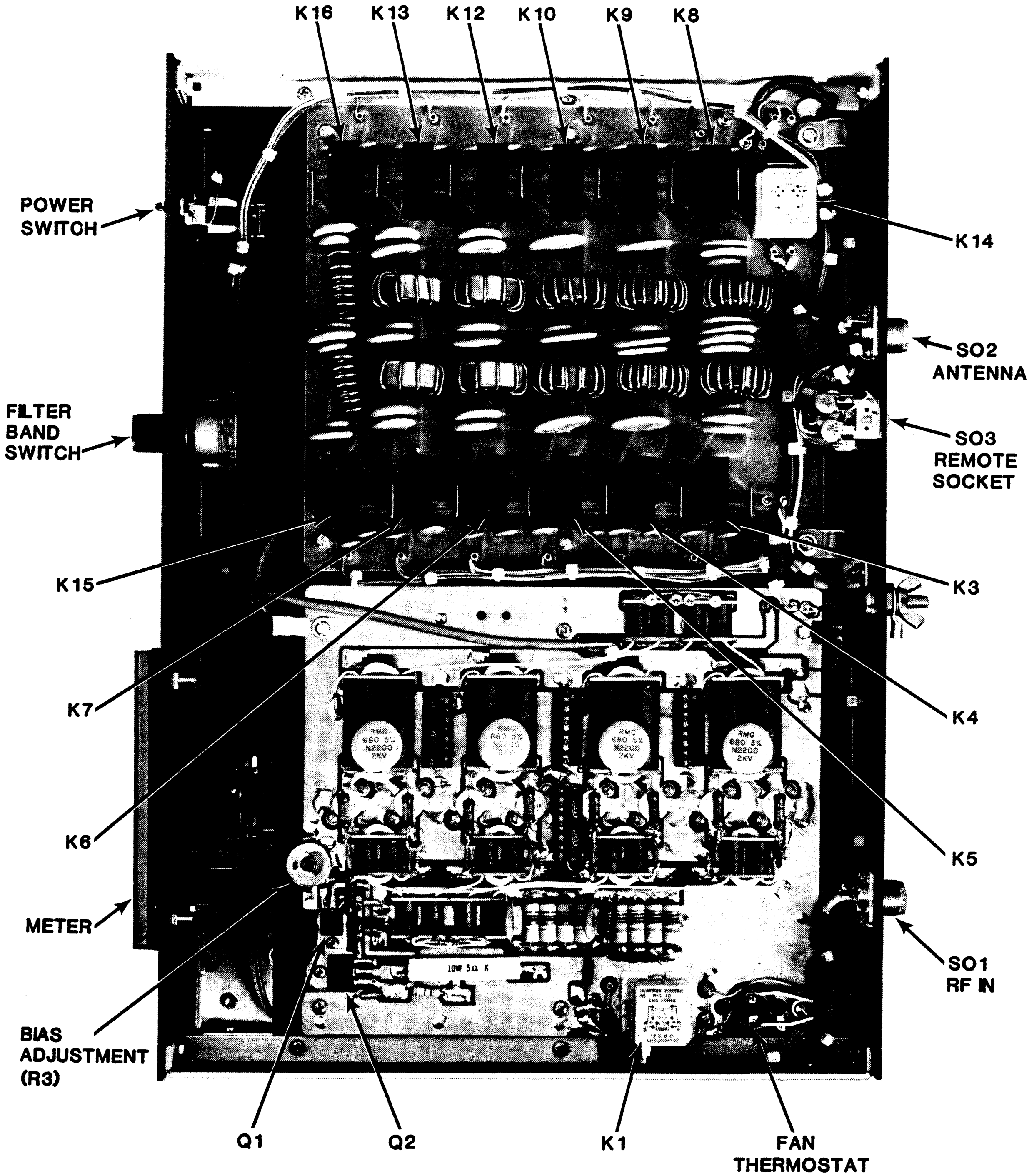



FIGURE 5-1.
Access to the Filter Board (Top) and Main Amplifier Board (Bottom) is Gained by Removing the Cover.

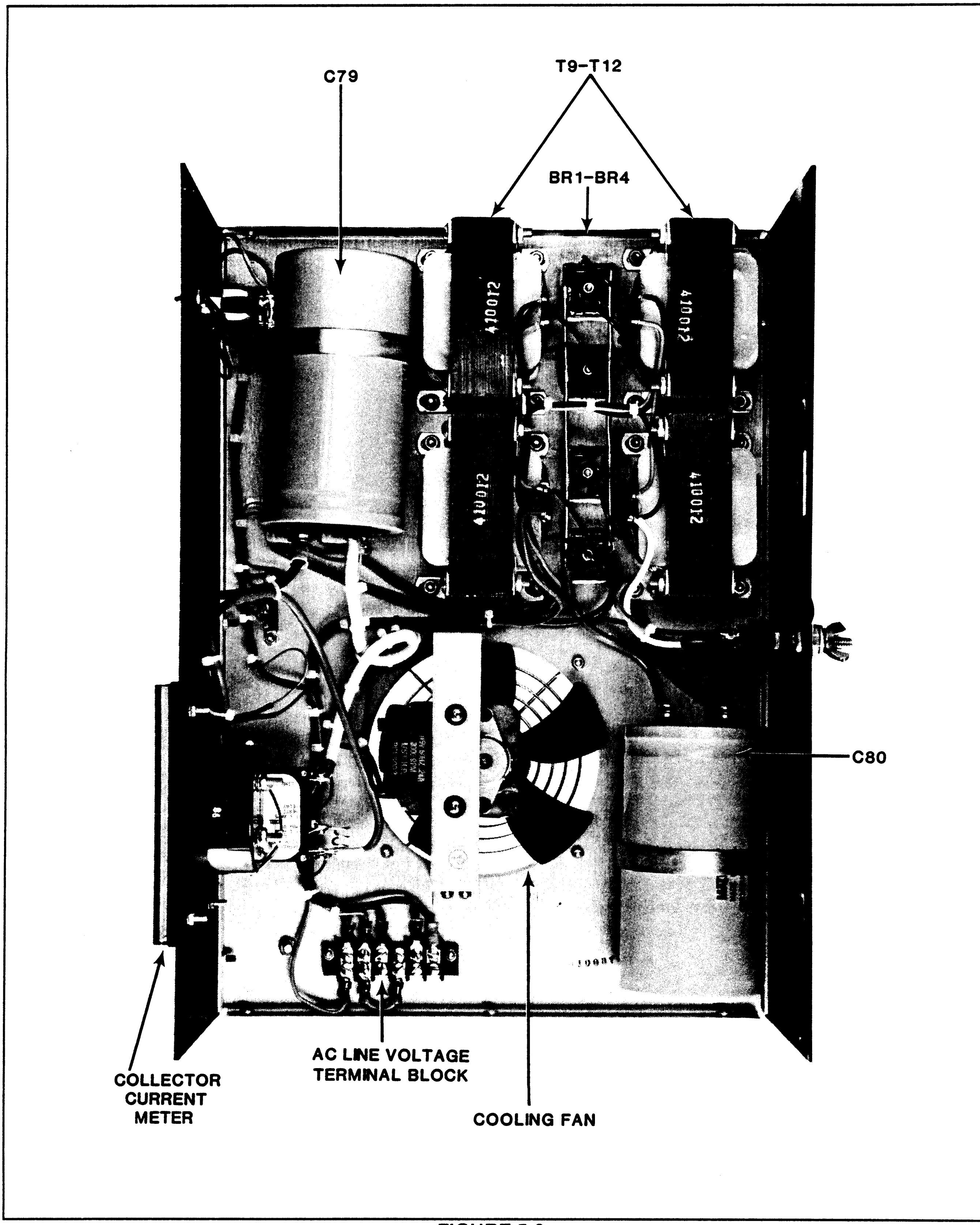



FIGURE 5-2.
Major Power Supply Components. Access is gained by lifting the heat sink and circuit board assembly out of the way.

F1, and can also be verified with an ohmmeter. Excessive leakage in the capacitors will be evidenced by heating.

### 5.6 BIAS CIRCUIT

The bias circuit applies a small positive voltage on the bases of the power transistors during the transmit mode. As a result, a low value of current (known as quiescent or idle current) will flow in the absence of drive. If the ac line voltage should change considerably, or if the bias sup-ply should fail, idle current could assume an abnormally high or low value. These conditions will cause either signal distortion and/or excessive heating of the amplifier.

Check that the total idle current is 3.5 A ± 0.5 A on the front panel meter. This is read with the PTT line grounded, and NO DRIVE APPLIED. If necessary, adjust the bias potentiometer R3 (Figure 5-1) until the idle current is correct. If this value is unattainable, measure the bias voltage at the bases of the transistors with the PTT line grounded (Figure 5-3). It should be approximately 0.625 Vdc. If the bias circuit does not appear to be operating correctly, check that the emitter/base differential of both Q1 and Q2 is approximately 0.7 Vdc. Any substantial variation indicates that the device is defective. The idle current should always be reset after a transistor replacement.

If the bias circuit is functioning, yet the proper amount of idle current cannot be set, the problem is most likely in one of the power transistors. Consult the following section.

### 5.7 AMPLIFIER SERVICE

#### 5.7.1 GENERAL

Low power output and abnormal collector current are sure indicators of a fault in one of the amplifiers. Failure of one of the four sections will cause the TW500A to run at 50% output, rather than 75% as one might expect. Unbalance in the output combiner will cause one additional section to dissipate full power in the balance resistors, R25-R28.

A faulty power transistor can be located by one of two following methods, depending on the test equipment available.

#### 5.7.2 DC FAULT TRACING

This method of troubleshooting is the more time-consuming of the two, but only requires an ohmmeter. If a certain transistor is suspected faulty, begin with that one. Otherwise, start with the transistor at one end of the circuit board and move to the next, one at a time.

With POWER OFF, move the R/C network above the transistor by unsoldering the capacitor lead from the base and swinging both components to one side (Figure 5-3). Carefully unsolder the base lead and lift it away from the circuit board. Check the resistance from the base to the emitter in both directions by alternating the ohmmeter leads. Do the same between the base and collector. A good transistor will show high resistance (several thousand ohms) in one direction, and relatively low (under 100 ohms) in the other. Faulty devices will show either a high or low resistance in both directions. Refer to section 5.7.5 for transistor replacement.

#### 5.7.3 AC SIGNAL FAULT TRACING

This method of troubleshooting is much faster than the previous one, but requires a two-tone RF signal generator and 15-MHz oscilloscope. Remove all power from the amplifier, and connect the signal generator to SO1, the RF input. Inject approximately 20 dBm of 5-MHz, two-tone RF. Probe the base of each transistor with the oscilloscope, making note of the RF envelope level (Figure 5-3). The faulty device will show a signal level that is significantly different from the rest. Replace the faulty transistor per Section 5.7.5.

#### 5.7.4 AMPLIFIER CIRCUIT BOARD

Most of the amplifier components can be replaced without removing the circuit board. If it is necessary to lift the circuit board, remove the two mounting screws holding the circuit breaker and swing it clear. Remove the six circuit board retaining screws, the sixteen RF power transistor screws and the two bias transistor mounting screws. The circuit board can now be lifted.

Take special care when replacing the board, ensuring that adequate heat sink compound is under the transistors and that no strain is exerted on the transistor leads when the mounting screws are tightened.

#### 5.7.5 RF TRANSISTOR REPLACEMENT

The R/C network mounted above each transistor must first be moved by unsoldering the capacitor from the transistor base and swinging both components to one side. One at a time, unsolder the transistor leads, taking care not to damage the circuit board foil. It is helpful to use a desoldering tool to remove as much solder as possible and then carefully lift the lead up from the board while the solder is molten. Remove the two mounting screws and lift out the transistor.

***IMPORTANT!***

Whenever possible, power transistors should be replaced in beta-matched pairs. If it is only possible to replace one unit, make sure that it has the same beta coding as the other transistor in the pair. The beta code is usually indicated by a colored dot on the case.

Trim the replacement transistor leads to fit the circuit board and liberally coat the mounting base with heat sink compound. Carefully position the transistor with the collector lead toward the output transformer. Replace and tighten the two mounting screws. Check that there is no strain on the transistor leads and solder them in place. The iron should be large enough to melt the solder rapidly. If it is too small, a prolonged application will be necessary, which provides sufficient time for heat to be conducted through the leads, and may cause damage to the transistor.

After the defective amplifier has been repaired, check the output combiner balance resistors. The resistors will usual-

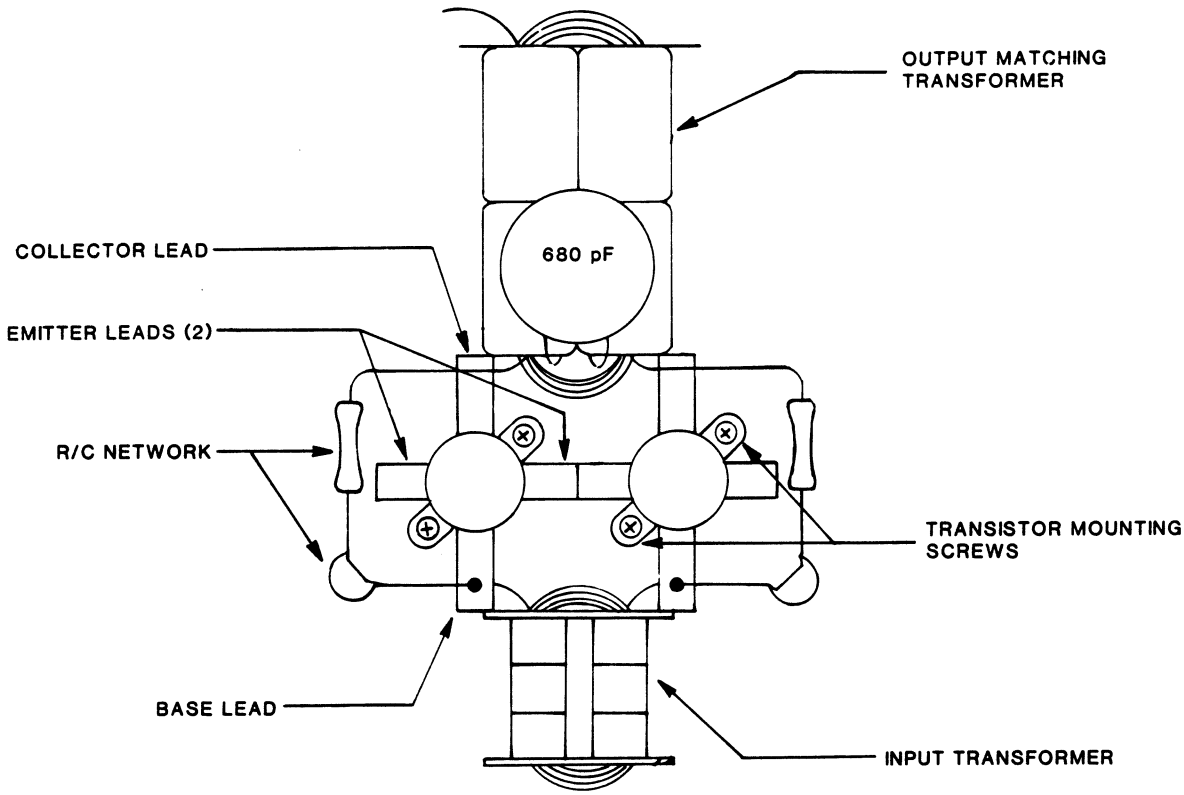



**FIGURE 5-3.**
**Detail of a Push-Pull Amplifier Section.**

ly take moderate overload without damage. However, it is advisable to check the resistance of any that show evidence of overheating.

## 5.8 FILTERS

### 5.8.1 GENERAL

A filter defect will usually be apparent on only one frequency range. If so, check operation of the filter input and output relays and condition of all filter components. Because of the relatively high power levels, filter components will often overheat and discolor when faulty. If the defect is present on more than one range, check the wiring and operation of filter switch S1 (desk-top models only), and check for sticking relay contacts.

### 5.8.2 FILTER BOARD REMOVAL

The filter board (Figure 5-1) may be removed for relay or filter component replacement by removing the six screws holding it to the heat sink. Lifting the board usually gives sufficient access to the underside for component replacement. If necessary, the appropriate cables can be temporarily disconnected to provide further clearance.

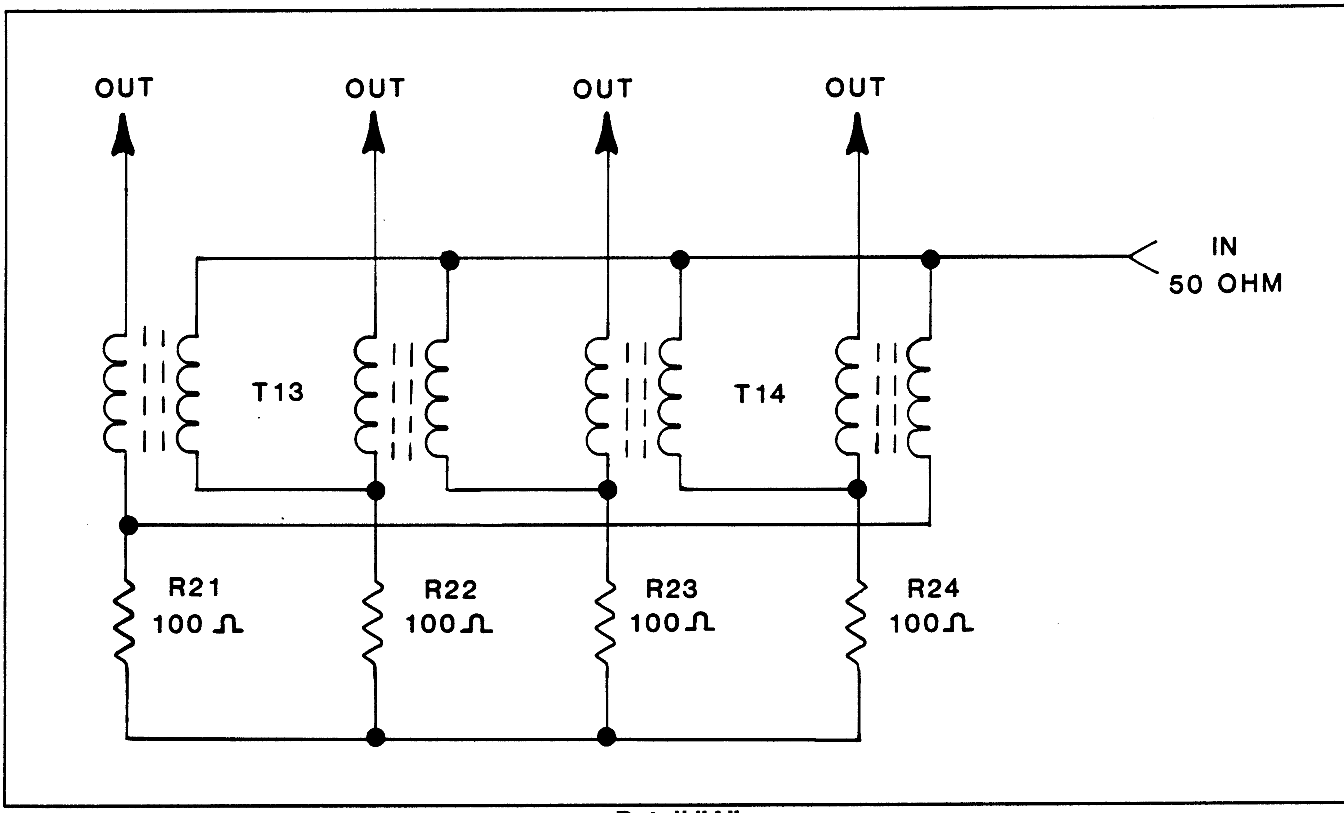
# SECTION 6
# PARTS LISTS AND SCHEMATIC DIAGRAMS

## 6.1 INTRODUCTION

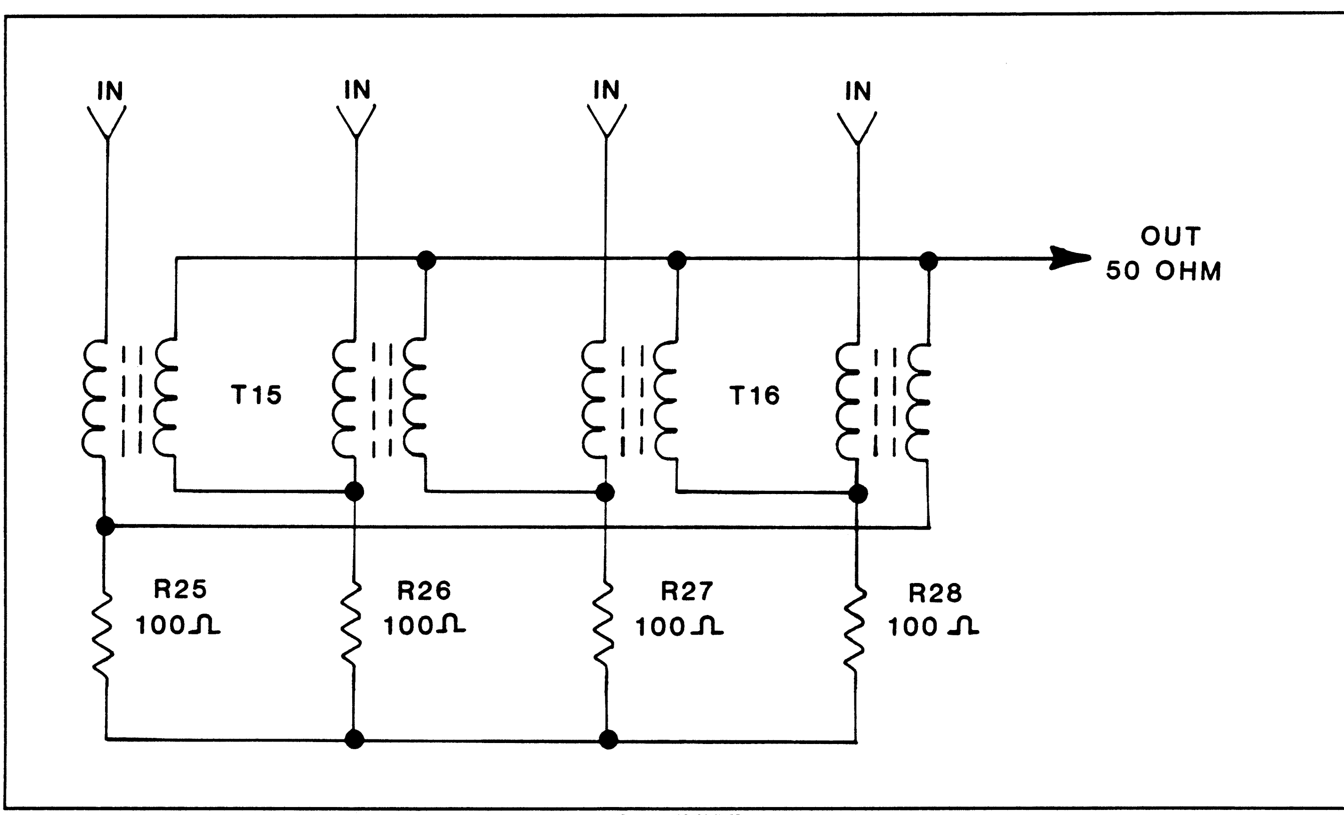
This section contains the schematic diagrams and parts lists for the TW500A linear amplifier.

The contents of Section 6 are summarized below:

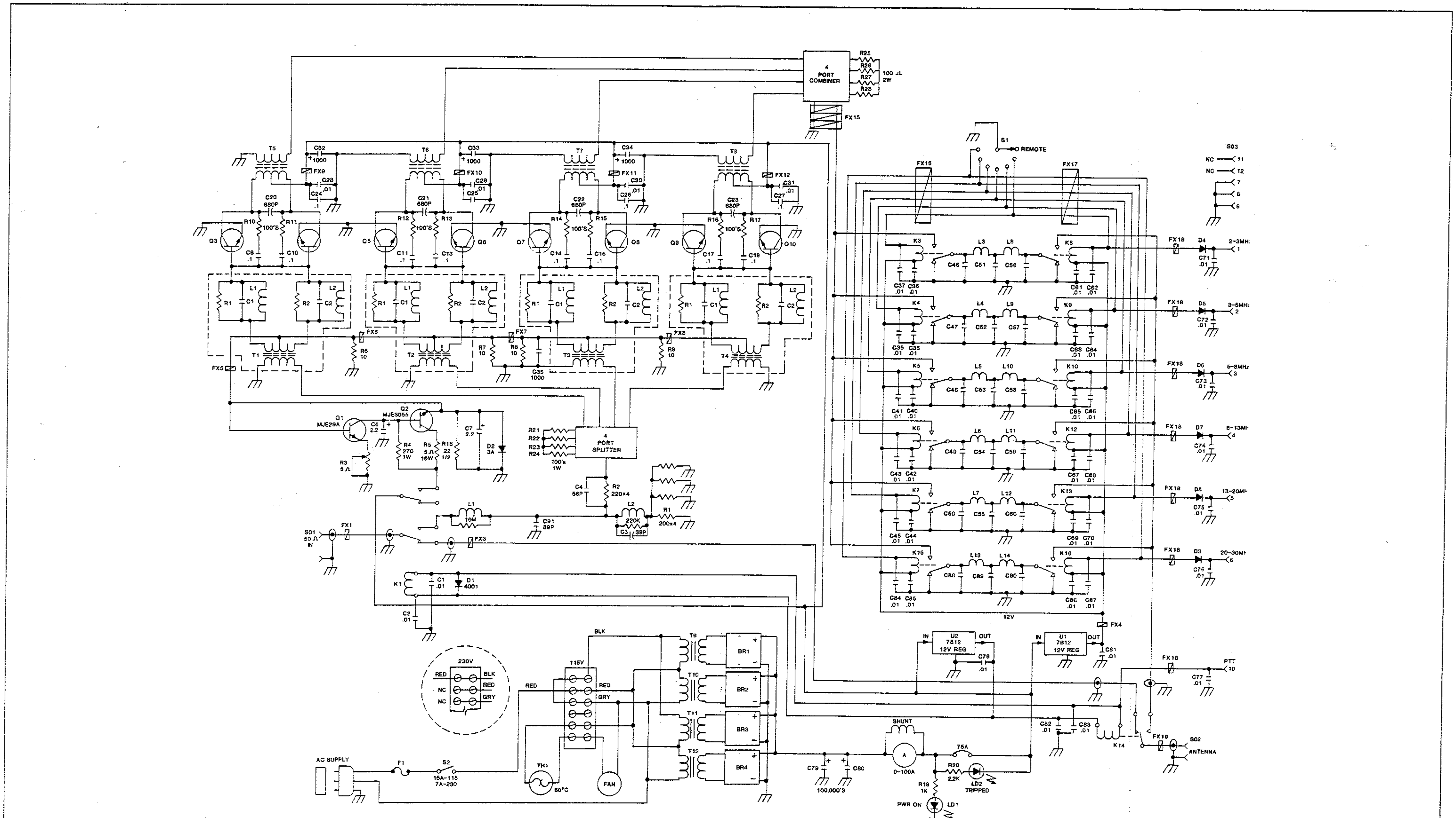
| DESCRIPTION | SCHEMATIC DIAGRAM - FIGURE | PARTS LIST - TABLE |
|---|---|---|
| TW500A Linear Amplifier | 6-1 | 6-1 |
| TW500A Input Splitter Subassembly | Detail "A" | 6-1 |
| TW500A Output Combiner Subassembly | Detail "B" | 6-1 |
| Filter Board | 6-1 | 6-2 |
| SWR1000 Forward/Reverse Power Bridge | 6-2 | 6-3 |




Detail "A"
TW500A Input Splitter Subassembly.




Detail "B"
TW500A Output Combiner Subassembly.



2. CAPACITANCE IS IN MICROFARADS.
1. RESISTANCE IS IN OHMS.
NOTES: UNLESS OTHERWISE SPECIFIED

FIGURE 6-1.
Schematic Diagram, TW500A Linear Amplifier (See details at left).

**TABLE 6-1.**
**Parts List, TW500A Linear Amplifier.**

| | | |
|---|---|---|
| C1, C2 | 211103 | Capacitor, Ceramic Disc 500 V 0.01 μF |
| C3 | 212390 | Capacitor, Ceramic Disc 5 kV 39 pF |
| C4 | 212560 | Capacitor, Ceramic Disc 3 kV 56 pF |
| C5 | | Not Used. |
| C6, C7 | 241020 | Capacitor, Tantalum 16 V 2.2 μF |
| C8 | 210104 | Capacitor, Ceramic Disc 0.1 μF |
| C9 | | Not Used. |
| C10, C11 | 210104 | Capacitor, Ceramic Disc 0.1 μF |
| C12 | | Not Used. |
| C13, C14 | 210104 | Capacitor, Ceramic Disc 0.1 μF |
| C15 | | Not Used. |
| C16, C17 | 210104 | Capacitor, Ceramic Disc 0.1 μF |
| C18 | | Not Used. |
| C19 | 210104 | Capacitor, Ceramic Disc 0.1 μF |
| C20-C23 | 212681 | Capacitor, Ceramic Disc 2 kV 680 pF |
| C24-C27 | 210104 | Capacitor, Ceramic Disc 0.1 μF |
| C28-C31 | 211103 | Capacitor, Ceramic Disc 0.01 μF |
| C32-C35 | 230102 | Capacitor, Electrolytic 25 V 1000 μF |
| C36-C70 | | See Filter Parts List. |
| C71-C77 | 211103 | Capacitor, Ceramic Disc 500 V 0.01μF |
| C78 | 210104 | Capacitor, Ceramic Disc 0.1 μF |
| C79, C80 | 230104 | Capacitor, Electrolytic 30 V 100,000 μF |
| C81 | 210104 | Capacitor, Ceramic Disc 0.1 μF |
| C82-C90 | | See Filter Parts List. |
| C91 | 220390 | Capacitor, Mica 39 pF |
| CB1 | 570004 | Circuit Breaker |
| D1 | 320102 | Diode, 1N4001 |
| D2 | 320103 | Diode, 50 V 3 A |
| D3-D8 | 320101 | Diode, 1N4005 |
| F1 | 550006 | Fuse, 15 A (115 Vac) |
| | 550008 | Fuse 7 A (230 Vac) |
| FX1 | 490501 | Sleeve, Ferrite |
| FX2 | | Not Used. |
| FX3 | 490501 | Sleeve, Ferrite |
| FX4 | 490302 | Bead, Ferrite |
| FX5-FX12 | 490202 | Bead, Ferrite |
| FX13, FX14 | | Not Used. |
| FX15 | 490302 (3 per) | Bead, Ferrite |
| FX16, FX17 | 490302 | Bead, Ferrite |
| FX18 | 490302 (2 per) | Bead, Ferrite |
| FX19 | 490501 | Sleeve, Ferrite |
| K1 | 540005 | Relay, DPDT 5 A Contacts, 12 Vdc Coil |
| K2 | | Not Used. |
| K3-K10 | | See Filter Parts List. |
| K11 | | Not Used. |
| K12-K14 | | See Filter Parts List. |
| L1 | 430101 | Inductor, 8 turns over 10 M Resistor |
| L2 | 430203 | Inductor, 17 turns over 220 K Resistor |
| L3-L12 | | See Filter Parts List. |

**TABLE 6-1.**
**Parts List, TW500A Linear Amplifier, Continued.**

| | | |
|---|---|---|
| LD1, LD2 | 320402 | LED, red |
| M1 | 740004 | Meter, 0-100 A |
| Q1 | 310024 | Transistor, MJE29A |
| Q2 | 310025 | Transistor, MJE3055K |
| Q3-Q10 | 310071 | Transistor, RF Power 100 W |
| R1 | 153201 (4 per) | Resistor, Film 2 W 5% 200 Ω |
| R2 | 153221 (4 per) | Resistor, Film 2 W 5% 220 Ω |
| R3 | 170301 | Resistor, Potentiometer 5 Ω |
| R4 | 144271 | Resistor, Film 1 W 5% 270 Ω |
| R5 | 160050 | Resistor, Wirewound 10 W 5% 5 Ω |
| R6-R9 | 124100 | Resistor, Film 1/4 W 5% 10 Ω |
| R10-R17 | 154101 | Resistor, Film 2 W 5% 100 Ω |
| R18 | 134220 | Resistor, Film 1/4 W 5% 10 Ω |
| R19 | 124102 | Resistor, Carbon 1/4 W 2 kΩ |
| R20 | 124222 | Resistor, Film 1/4 W 5% 2.2 kΩ |
| R21-R24 | 144101 | Resistor, Film 1 W 5% 100 Ω |
| R25-R28** | 154101 | Resistor, Film 1 W 5% 100 Ω |
| S1 | 510004 | Switch, Band Select |
| S2 | 530201 | Switch, Ac |
| SO1, SO2 | 610003 | Socket, SO-239 |
| SO3 | 610014 | Socket, 12 Pin |
| T1-T4*** | 450306 | Transformer, Ferrite Driver |
| T5-T8 | 450307 | Transformer, Ferrite Output |
| T5-T8† | 459159 | Transformer, Ferrite Output 6 turns |
| T9-T12 | 410012 | Transformer, Ac Power 12 V Special |
| T13, T14* | 700103 | Transformer, Splitter/Combiner Pair |
| T15, T16** | 700103 | Transformer, Splitter/Combiner Pair |
| TH1 | 560002 | Thermostat, N/O (normally-open) 60oC Trip |
| | 910020 | Heatsink |
| | 731010 | Circuit Board, Amplifier |
| | 731011 | Circuit Board, Filter |
| | 700003 | Motor, Fan Blade |
| BR1-BR4 | 320501 | Rectifier Bridge, 100 V 35 A |
| U1, U2 | 330007 | IC, Regulator 7812CP |

* Part located on splitter subassembly.
**Part located on combiner subassembly.
† Part used in TW100-FSK option.
***T1-T4 comprised of:

| | | |
|---|---|---|
| C1,C2 | 215222 | Capacitor, Chip Ceramic 0.0022 μF |
| L1,L2 | 459114 | Inductor, Ferrite 6 turns |
| R1,R2 | 134056 | Resistor, Film 1/2 W 5% 5.6 Ω |

**TABLE 6-2.**
**Parts List, TW500A Filter Board.**

| | | |
|---|---|---|
| C36-C45 | 211103 | Capacitor, Ceramic Disc 500 V 0.01 µF |
| C46, C56 | 212151 | Capacitor, Ceramic Disc 4 kV 150 pF |
| | 212431 | Capacitor, Ceramic Disc 2 kV 430 pF |
| | 212681 | Capacitor, Ceramic Disc 2 kV 680 pF |
| C47, C57 | 212751 | Capacitor, Ceramic Disc 2 kV 750 pF |
| C48, C58 | 212471 | Capacitor, Ceramic Disc 2 kV 470 pF |
| C49, C59 | 212221 | Capacitor, Ceramic Disc 3 kV 220 pF |
| | 212680 | Capacitor, Ceramic Disc 5 kV 68 pF |
| C50, C60 | 212121 | Capacitor, Ceramic Disc 3 kV 120 pF |
| | 212680 | Capacitor, Ceramic Disc 5 kV 68 pF |
| C51 | 212221 | Capacitor, Ceramic Disc 3 kV 220 pF |
| | 212431 | Capacitor, Ceramic Disc 2 kV 430 pF |
| | 212751 | Capacitor, Ceramic Disc 2 kV 750 pF |
| | 212751 | Capacitor, Ceramic Disc 2 kV 750 pF |
| C52 | 212151 | Capacitor, Ceramic Disc 4 kV 150 pF |
| | 212471 | Capacitor, Ceramic Disc 2 kV 470 pF |
| | 212681 | Capacitor, Ceramic Disc 2 kV 680 pF |
| C53 | 212560 | Capacitor, Ceramic Disc 3 kV 56 pF |
| | 212391 | Capacitor, Ceramic Disc 2 kV 390 pF |
| | 212391 | Capacitor, Ceramic Disc 2 kV 390 pF |
| C54 | 212431 | Capacitor, Ceramic Disc 2 kV 430 pF |
| | 212680 | Capacitor, Ceramic Disc 5 kV 68 pF |
| C55 | 212271 | Capacitor, Ceramic Disc 2 kV 270 pF |
| | 212560 | Capacitor, Ceramic Disc 3 kV 56 pF |
| C61-C87 | 211103 | Capacitor, Ceramic Disc 500 V 0.01 µF |
| C88A | 212560 | Capacitor, Ceramic Disc 3 kV 56 pF |
| C88B | 212680 | Capacitor, Ceramic Disc 5 kV 68 pF |
| C89 | 212121 | Capacitor, Ceramic Disc 3 kV 120 pF |
| | 212560 | Capacitor, Ceramic Disc 3 kV 56 pF |
| | 212390 | Capacitor, Ceramic Disc 5 kV 39 pF |
| C90A | 212560 | Capacitor, Ceramic Disc 3 kV 56 pF |
| C90B | 212680 | Capacitor, Ceramic Disc 5 kV 68 pF |
| K3-K10 | 540013 | Relay, SPDT 12 Vdc Coil, 10 A Contacts |
| K11 | | Not Used. |
| K12-K16 | 540013 | Relay, SPDT 12 Vdc Coil, 10 A Contacts |
| L3, L8 | 450608 | Inductor, 2-3 MHz |
| L4, L9 | 450607 | Inductor, 3-5 MHz |
| L5, L10 | 450606 | Inductor, 5-8 MHz |
| L6, L11 | 450508 | Inductor, 8-13 MHz |
| L7, L12 | 430604 | Inductor, 13-20 MHz |
| L13, L14 | 430201 | Inductor, 20-30 MHz |

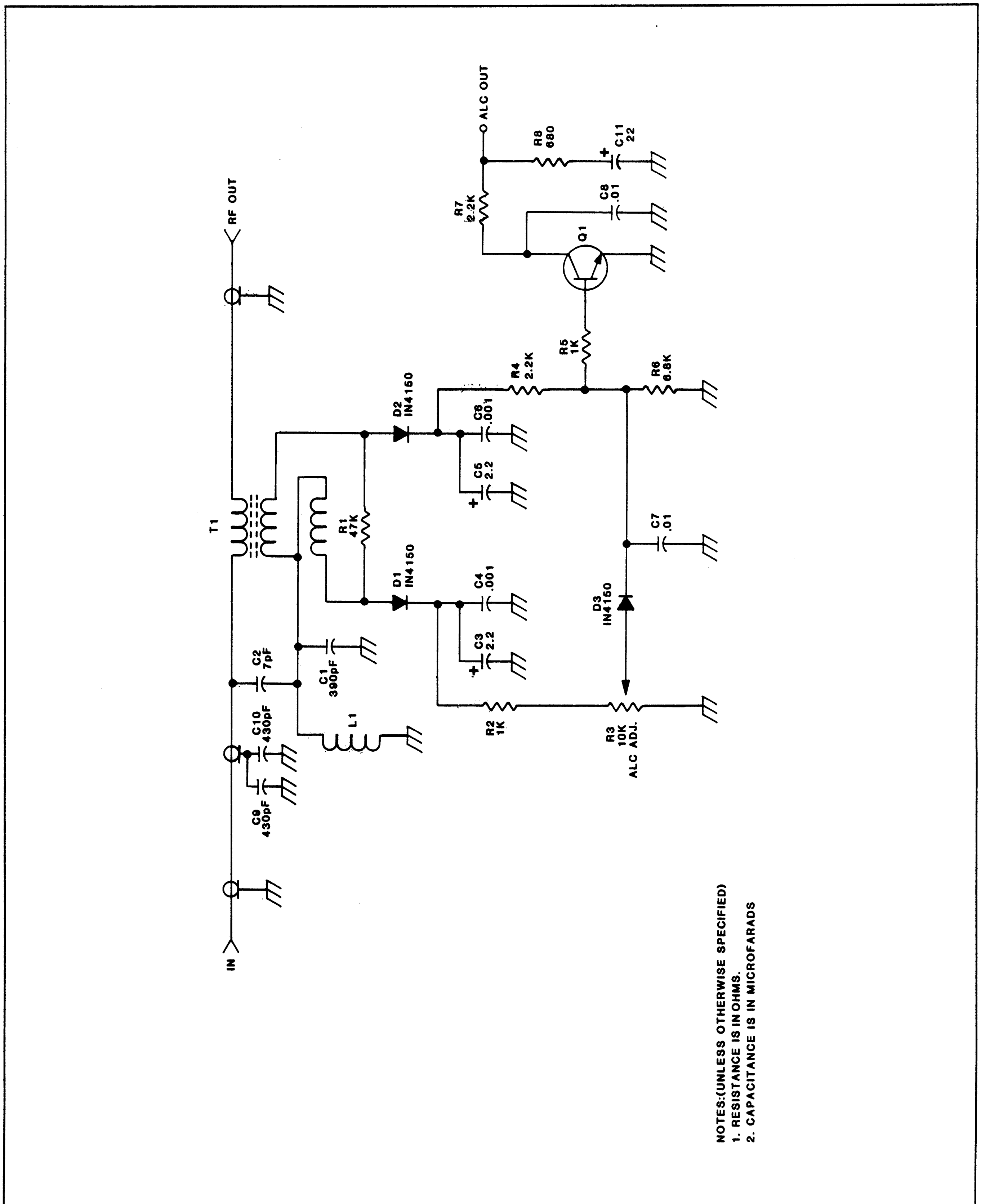



**FIGURE 6-2.**
**Schematic Diagram, SWR1000 Power Bridge.**

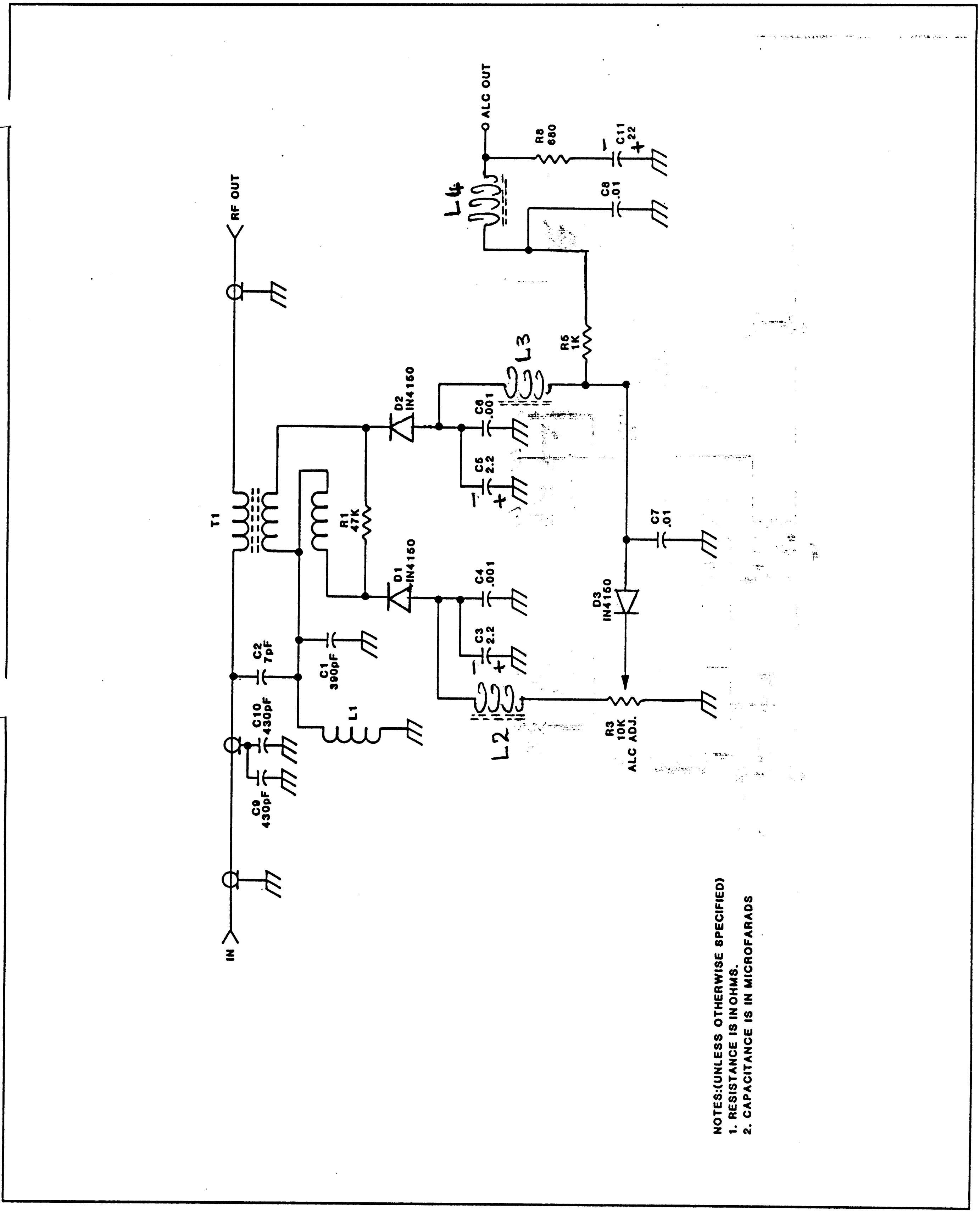



FIGURE 6-2.A,
Schematic Diagram, SWR1000 Power Bridge.

**TABLE 6-3.**
**Parts List, SWR1000.**

| | | |
|---|---|---|
| C1 | 212391 | Capacitor, Disc 390 pF |
| C2 | 210070 | Capacitor, Disc 7 pF |
| C3 | 241020 | Capacitor, Tantalum 2.2 μF |
| C4 | 220102 | Capacitor, Mica 1000 pF |
| C5 | 241020 | Capacitor, Tantalum 2.2 μF |
| C6 | 220102 | Capacitor, Mica 1000 pF |
| C7,C8 | 210103 | Capacitor, Disc 0.01 μF |
| C9,C10 | 220431 | Capacitor, Mica DM15 430 pF |
| C11 | 241226 | Capacitor, Tantalum 22 μF |
| D1-D3 | 320002 | Diode, 1N4148 |
| J1,J2 | 610003 | Connector |
| Q1 | 310027 | Transistor, 2N5306 |
| R1 | 124470 | Resistor, Film 1/4 W 5 % 47 Ω |
| R2 | 124102 | Resistor, Film 1/4 W 5 % 1 kΩ |
| R3 | 170114 | Resistor, Trimmer 10 kΩ |
| R4 | 124222 | Resistor, Film 1/4 W 5 % 2.2 kΩ |
| R5 | 124102 | Resistor, Film 1/4 W 5 % 1 kΩ |
| R6 | 124582 | Resistor, Film 1/4 W 5 % 6.8 kΩ |
| R7 | 124222 | Resistor, Film 1/4 W 5 % 2.2 kΩ |
| R8 | 124681 | Resistor, Film 1/4 W 5 % 680 Ω |